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A TERRITORIAL MODEL OF COMMUTING IN CATALONIA, 1986-1996

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ABSTRACT

Commuting consists in the fact that an important fraction of workers in developed countries do not reside close to their workplaces but at long distances from them, so they have to travel to their jobs and then back home daily. Although most workers hold a job in the same municipality where they live or in a neighbouring one, an important fraction of workers face long daily trips to get to their workplace and then back home.

Even if we divide Catalonia (Spain) in small aggregations of municipalities, trying to make them as close to *local labour markets* as possible, we will find out that some of them have a positive commuting balance, attracting many workers from other areas and providing local jobs for almost all their resident workers. On the other side, other zones seem to be mostly residential, so an important fraction of their resident workers hold jobs in different *local labour markets*.

Which variables influence an area's role as an attraction pole or a residential zone? In previous papers (Artís *et al*, 1998*a*, 2000; Romaní, 1999) we have brought out the main individual variables that influence commuting by analysing a sample of Catalan workers and their commuting decisions. In this paper we perform an analysis of the territorial variables that influence commuting, using data for aggregate commuting flows in Catalonia from the 1991 and 1996 Spanish Population Censuses.

These variables influence commuting in two different ways: a zone with a dense, well-developed economical structure will have a high density of jobs. Work demand cannot be fulfilled with resident workers, so it spills over local boundaries. On the other side, this economical activity has a series of side-effects like pollution, congestion or high land prices which make these areas less desirable to live in. Workers who can afford it may prefer to live in less populated, less congested zones, where they can find cheaper land, larger homes and a better quality of life. The penalty of this decision is an increased commuting time.

Our aim in this paper is to highlight the influence of local economical structure and amenities endowment in the workplace-residence location decision. A place-to-place logit commuting models is estimated for 1991 and 1996 in order to find the economical and amenities variables with higher influence in commuting decisions. From these models, we can outline a first approximation to the evolution of these variables in the 1986-1996 period. Data have been obtained from aggregate flow travel-matrix from the 1986, 1991 and 1996 Spanish Population Censuses.

RESUMEN

La *movilidad laboral obligada* (traducción de la palabra inglesa *commuting*) consiste en el fenómeno de que una proporción elevada de los trabajadores de los países desarrollados no trabajan cerca de sus domicilios, sino a distancias relativamente elevadas de éstos, de forma que tienen que desplazarse diariamente, primero desde su domicilio a su puesto de trabajo, y luego al revés. Aunque la mayor parte de los trabajadores tienen su puesto de trabajo en su domicilio de residencia o en un municipio adyacente, una proporción importante de los trabajadores afronta diariamente desplazamientos relativamente largos para acceder a su puesto de trabajo y después, para volver a su hogar.

Aún dividiendo Cataluña en pequeñas agrupaciones de municipios, intentando que éstas sean lo más aproximadas posible a los *mercados de trabajo locales*, nos encontramos con que algunas tendrán un saldo de movilidad positivo, de forma que atraerán a trabajadores de otras áreas, mientras que casi todos los trabajadores residentes tienen un puesto de trabajo en su área de residencia. En cambio, otras zonas parecen sobre todo residenciales, de forma que una parte importante de los trabajadores residentes tiene su puesto de trabajo en *mercados de trabajo locales* distintos.

¿Qué variables influyen en la caracterización de una zona como polo de atracción de trabajadores o como zona residencial? En trabajos previos (Artís *et al*, 1998*a*, 2000; Romaní, 1999) hemos estudiado las variables que influyen la decisión individual de movilidad, analizando una muestra de trabajadores catalanes y de sus decisiones de movilidad. En este documento, se presenta un estudio de las variables de tipo territorial que influyen en le movilidad, usando datos de los flujos de movilidad agregados, procedentes del Censo de Habitantes de 1991 y del Padrón de 1996.

Dichas variables influyen en la movilidad por dos vías diferentes: una zona con una estructura económica densa y bien desarrollada tendrá una elevada densidad de puestos de trabajo.

La demanda de trabajo no puede cubrirse sólo con la oferta de trabajadores residentes, de manera que se extiende a las demarcaciones vecinas. Por otro lado, la actividad económica tiene una serie de efectos secundarios, tales como contaminación, congestión o elevados precios de la vivienda, que convierten estas áreas en menos atractivas desde el punto de vista residencial. Los trabajadores que puedan permitírselo, preferirán vivir en zonas menos pobladas y congestionadas, donde puedan encontrar precios del suelo más baratos, viviendas más grandes y equipadas, y mejor calidad de vida. A cambio de estas ventajas tendrán que soportar mayor tiempo y costes de desplazamiento diario.

El objetivo de este trabajo es destacar la influencia de la estructura económica local y de las variables que afectan a la calidad de vida en la decisión de elección de lugar de residencia y lugar de trabajo. Para ello, se estima un modelo logit territorial (*place-to-place*) para 1991 y 1996, con el objetivo de encontrar las variables económicas y de calidad de vida con mayor influencia en las decisiones de movilidad. A partir de estos modelos, podemos definir una aproximación a la evolución de estas variables y su efecto en la movilidad en el período 1986-1996.

RESUM

La *mobilitat laboral obligada* (traducció de la paraula anglesa *commuting*) consisteix en el fenomen que una proporció molt elevada dels treballadors dels països desenvolupats no treballen a prop dels seus domicilis, sinó a distàncies relativament elevades d'aquests, de manera que s'han de desplaçar diàriament per accedir al seu lloc de treball, i després, per tornar a las seva llar.

Encara si dividim Catalunya en petites agrupacions de municipis, intentant que aquestes siguin el més aproximades possible a *mercats de treball locals*, trobarem que algunes d'aquestes agrupacions tindran un saldo de mobilitat positiu, de manera que atrauran treballadors d'altres àrees, al mateix temps que gairebé tots els treballadors residents troben un lloc de treball a las seva àrea de residència. En canvi, altres zones semblen tenir un perfil més residencial, de manera que una past important dels treballadors residents tenen el seu lloc de treball a altres *mercats de treball locals*.

Quines són les variables que influeixen en la caracterització d'una zona com pol d'atracció de treballadors o com zona residencial? En treballs anteriors (Artís *et al*, 1998*a*, 2000; Romaní, 1999) hem estudiat les variables que influeixen en la decisió individual de mobilitat, analitzant una mostra de treballadors catalans i de les seves decisions de mobilitat. En aquest document es presenta un estudi de les variables de tipus territorial que influeixen en la mobilitat, utilitzant dades de fluxos de mobilitat agregats, que provenen del Cens d'Habitants de 1991 i del Padró de 1996.

Les esmentades variables influeixen en la mobilitat per dues vies diferents: una zona amb una estructura econòmica densa i ben desenvolupada tindrà una elevada densitat de llocs de treball. La demanda de treball no es pot cobrir només amb la oferta de treballadors residents, de manera que s'extén a les zones veïnes. D'altra banda, l'activitat econòmica té un seguit d'efectes secundaris (com contaminació, congestió o elevats preus de l'habitatge) que les converteixen en menys atractives des del punt de vista residencial. Els treballadors que pugin permetre-s'ho preferiran viure a zones menys poblades i congestionades, on es poden trobar preus de l'habitatge més reduïts, habitatges més grans i millor equipats, i millor qualitat de vida. A canvi d'aquests avantatges tindran que suportar més temps i costos de desplaçament diari.

L'objectiu d'aquest treball és destacar la influència de l'estructura econòmica local i de les variables que afecten la qualitat de vida en la decisió d'elecció del lloc de residència i del lloc de treball. Amb aquesta finalitat, s'ha estimat un model logit territorial (*place-to-place*) per els anys 1991 i 1996, amb l'objectiu de trobar les variables econòmiques i de qualitat de vida amb més influència en la decisió de mobilitat. A partir d'aquests models podem definir una aproximació a l'evolució d'aquestes variables i el seu efecte en la mobilitat en el període 1986-1996.

A TERRITORIAL MODEL OF COMMUTING IN CATALONIA, 1986-1996

1.- Introduction

A distinctive feature of modern societies and economies is the separation between homes and workplaces, which obliges workers to commute. For most workers, these daily trips are not excessively long; for example, in 1996, 58.14% of Catalan workers lived and worked in the same municipality. This has led to the concept of local labour markets (also known as travel-to-work areas or daily urban systems), defined as zones with a high level of auto-sufficiency in which most jobs in the zone are occupied by residents, and most residents in the zone do not out-commute. Nonetheless, a significant proportion of workers work and live in different local labour markets.

Thus, we can expect to find sizeable commuting flows across administrative boundaries. Usually, inflows and outflows will not be balanced: some local authorities will become attraction poles (*centres*), receiving a large number of commuters from other zones, while other local authorities will adopt a more residential profile, with a substantial fraction of resident workers out-commuting.

Catalonia (see figure 1) is one of Spain's most urbanised and developed regions. It has more commuters than other urban zones with similar levels of income, such as Madrid or Valencia (in 1991, 36.19% of Catalan workers lived and worked in different municipalities, compared with 29.6% in Madrid and 25% in Valencia). As is the case in several other economic fields, Catalan commuting patterns are likely to “show the way” for other Spanish and European regions[1] in the near future.

Catalonia is divided into 41 *comarcas*, or small aggregations of municipalities (smaller than NUTS-3 level, see figure 2). Municipalities are heterogeneous in surface area, population, and jobs. Hardly any of them are large enough in extension and population to be considered *local labour markets* (the average extension of Catalan municipalities in 1996 was 33.78 km^2, and the average population 7,014). On the other hand, *comarcas* are larger (with an average extension of 777.92 km^2 and an average population of 161,512 in 1996), and more homogeneous, and most of them can be considered *local labour markets* (Palacio, 1998); as a result, we chose *comarcas* as the main territorial unit of our analysis.

The role of a zone (in our case, a *comarca*) is determined both by its economic structure (which will make the zone more or less attractive for commuters from other zones as a place to work) and its quality of life (which will determine whether workers and families find it a suitable place to live or not).

Commuting patterns changed gradually in Catalonia over the 1986-1996 period: while in 1986 most commuting took place between Barcelona and its Metropolitan Area (which includes the whole of the Barcelonès *comarca* and part of the surrounding *comarcas*), during the period under study the phenomenon extended throughout Catalonia. Other zones have consolidated their role as *centres*, although Catalonia is still a relatively

[1] Together with Baden-Württemberg (Germany), Lombardy-Piedmont (Italy) and Rhône-Alpes (France) Catalonia belongs to the “Four motors for Europe” project. All four are highly similar, heavily industrial regions

monocentric region (in 1996, 41% of inter-*comarca* commuters had their workplace in the Barcelonès *comarca* and their home in another *comarca*).

Suburbanisation was an important trend in Catalonia in the 1986-1996 period, too: The Barcelonès *comarca* and all Barcelona's Metropolitan Area lost population (a small loss between 1986 and 1991 and a larger one in the 1991-1996 period). Workers who leave Barcelona are attracted by lower land prices, lower congestion levels and higher amenities of *comarcas* surrounding the city, although most of them continue to work in the capital (Sau, 1993; Artís *et al*, 1998*a*, 1998*b*; Módenes and Pascual, 1998; Mendizábal and Sánchez, 1998; Palacio *et al*, 1998; Asensio, 1999; García, 1999).

This evolution of commuting patterns and suburbanisation raises some important questions:

* What factors (amenities or land prices) make some *comarcas* more attractive than other to live in?
* Why do many suburban workers keep commuting to central *comarcas* instead of seeking "decentralised" jobs?
* Does the suburbanisation process "saturate" amenities in suburban *comarcas*?
* Are amenities capitalised into wages and land prices, as theory predicts?
* Did Catalan workers' preferences regarding home and workplace location change between 1986 and 1996?

In this paper we analyse the aggregate commuting flows in Catalonia, in order to answer these questions. First, in section 2, we briefly review the *standard urban model* and some theories explaining the suburbanisation trend. Then, in section 3, we present a descriptive analysis of Catalan commuting patterns and their evolution in the 1986-1996 period. The last part of our paper is the discussion (section 4) and estimation (section 5) of a model for commuting flows and their evolution over time. This model has been estimated with data from 1991 and 1996, in order to analyse changes in the influence of the explanatory variables. An outline of Catalan commuting trends in the 1986-1996 period can be deduced from the study. Finally, section 6 concludes.

We believe our econometric model can easily be adapted to study commuting in other regions that are comparable to Catalonia in terms of extension and population. Similar models have been used by Merriman and Hellerstein (1994) to study commuting in the Tokyo Metropolitan Area and by Gabriel *et al* (1987) to analyse internal migration in Israel, although we think our model presents certain improvements over previous studies.

The data come from Spanish Population Censuses of 1986, 1991 and 1996 and were supplied by the Institut d'Estadística de Catalunya (Institute of Statistics of Catalonia, IDESCAT).

2.- The standard urban model: a brief review

The *theory of residential location* (also known as *standard urban model* or, sometimes, the *Alonso-Mills-Muth model*) is the best known theory in the study of commuting. It explains why workers choose and prefer certain places to others as their places of residence. Its basis is the *monocentric model* (Alonso, 1964) and it suggests that workers have to choose between shorter commuting time and cheaper land prices for their homes. Land closer to the centre (where all jobs are assumed to be located) is associated with a shorter commuting time; it is therefore more desirable and in greater demand, and it will be divided in small lots with higher prices. As we move away from the centre the size of lots increases while the price per unit of land decreases (*density gradient*).

Later contributions by Mills, Muth and other authors (see Simpson, 1992) provided a more realistic version of the monocentric model. For example, Muth allows workers to have different wages. Hekman (1985) extends Muth's model by adding time constraints, while White's (1988) version of the model allows the decentralisation of jobs. However, White's model is still monocentric in the sense that commuters are restricted to follow the periphery → centre direction.

Alonso's model was a milestone in the urban studies field. It was used to study subjects as varied as the structure of cities, housing prices, and commuting. Alonso's seminal model has spawned many derivatives, refining the original and relaxing its original assumptions to make it more realistic. In spite of these refinements – by Mills, Muth, Hekman or White – the current model still closely resembles Alonso's.

In spite of their wide diffusion, monocentric models have been criticised and rejected by some researchers because of their apparent lack of realism. Some empirical studies such as Hamilton's (see Simpson, 1992) have cast doubts on their validity and have proposed alternative models. Many of these "new" urban models try to formulate a general scheme, able to include the monocentric model as a particular case. Examples are the "port-city" models (Koide's (1990), or Zheng's (1990)), polycentric models or Simpson's "island" model (1992). The problem is that, unlike the monocentric model, these versions have not yet been empirically tested.

These theories suggest certain explanations for the *suburbanisation* phenomenon: as land prices increase and congestion makes amenities less accessible to "central" residents, the latter may decide to decentralise their residence, seeking cheaper land and less congested amenities (Palumbo *et al*, 1990; Greenwood and Stock, 1990; Margo, 1992; Thuston and Yezer, 1992; Van der Laan, 1998; García, 1999; Asensio, 1999).

Some alternative models, such as Nakagome's (1991) or Turnbull's (1992), combine these features: in these models, workers live in suburbs and can decide to work either in the city centre or locally (that is, in the area in which they live). Although both models consider only one centre or *central business district*, this restriction can easily be relaxed, so the worker can choose either to work in the local labour market or to commute. Henceforth, the workplace variable (W_i) becomes a binary one (we will call it C_i), which represents the worker's choice whether or not to work in his local labour market. If we aggregate individual workers' decisions into commuting flows, we can use them as our dependent variable.

In section 4, we discuss and specify a model that allows us to test these hypotheses empirically, removing the model's more restrictive assumptions. The model has been estimated (in section 5) for the NUTS-II region of Catalonia, using aggregate commuting data from 1991 and 1996.

3.- A descriptive analysis of commuting patterns in Catalonia, 1986-1996

In tables 1 and 2 and in figures 3 and 4 we present some indexes of commuting for the 41 Catalan *comarcas* in the years 1986, 1991 and 1996: *percentage of* inter-*comarca commuting* (% of workers who live and work in different *comarcas*), *percentage of* intra-*comarca commuting* (% of workers who live and work in the same *comarca*, but not in the same municipality), and *aperture index* (for each *comarca*, the fraction of resident workers who work outside plus the workers from outside the *comarca* that commute into it, compared with the total of workers living in the *comarca*).

From these tables and figures we can see that commuting evolved slowly from a very centralised structure into a more dispersed one: in 1986, commuting was mostly restricted to the Metropolitan Area of Barcelona, and, to a lesser extent, to the other three provincial capitals[2] of Girona (the Gironès *comarca*), Lleida (the Segrià *comarca*) and Tarragona (the Tarragonès *comarca*). The commuting pattern was mainly monocentric, from the surrounding *comarcas* into the capitals: 44% of inter-*comarca* commuters chose Barcelona as their destination, and a further 7% another provincial capital. The rest of *comarcas* formed local labour markets with little connection. The proportion of workers who commuted across *comarca* borders was only 12.45% of the total. Only in 7 *comarcas* was the out-commuting level higher than 12%, while 13 *comarcas* had a positive commuting balance (meaning that the number of in-commuters was larger than the number of out-commuters). The commuting balance was less than 1% (positive or negative) of the resident workers for 20 of the 41 Catalan *comarcas*, while the aperture index was 24.91%, denoting very low commuting levels. The average commuting distance (for inter-*comarca* commuters) was 30.09 kilometres, while 89% of inter-*comarca* commuters went to a *comarca* adjacent to the one they lived in. Intra-*comarca* commuting accounted for 16.64% of Catalan workers.

By 1991 this situation had started to change: the inter-*comarca* commuting level had risen to 15.92%, intra-*comarca* commuting to 19.52%, and the aperture index to 31.85%. The average commute for inter-*comarca* commuters had increased by more than one kilometre (to 31.54 km.). The proportion of commuting between neighbouring *comarcas* fell from 89% to 87% of all inter-*comarca* commuters. Zones that had traditionally formed closed local labour markets were slowly beginning to integrate into a more global labour market. This trend was especially noticeable in *comarcas* on the outer periphery of the province capitals, such as Baix Penedès, Garraf and Maresme, in the Barcelona influence area, Pla de l'Estany and Selva (around Gironès, although the Selva *comarca* also has a strong commuting relationship with Barcelonès), Priorat and Conca de Barberà near Tarragonès, and Pla d'Urgell, Garrigues and Noguera near Segrià.

1991 was also remarkable for a change in a long-established trend: Barcelona (and the whole Barcelonès *comarca*) came to the end of a very

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[2] Catalonia is divided into four provinces (NUTS-III territorial units) with capitals in

long population growth cycle and started losing population (Sau, 1993; see table 2). This can be seen as the confirmation of the suburbanisation phenomenon in Catalonia. The population decrease was not significant between 1986 and 1991 (only 3% of the population of the Barcelonès *comarca* left in this time), but this new trend became consolidated in the following period (the population loss of the Barcelonès *comarca* amounted to 7.4% in the 1991-1996 period). Even though the total population of Barcelonès decreased, the number of resident workers increased between 1986 and 1991.

However, many workers and their families moved from Barcelonès to the surrounding *comarcas*, which showed major increases both in the population and in the number of resident workers. Most of these workers did not change jobs, a fact which partially explains the increase in commuting flows from these *comarcas* to Barcelonès.

Apart from the provincial capitals, other *comarcas* had started to change their role, becoming economic poles that attracted commuting flows from the neighbouring zones: for instance, the Vallès Occidental and Vallès Oriental *comarcas*, both close to Barcelona and with a high level of industrial specialisation, showed positive commuting balances in 1991. The direction of commuting flows in the Barcelona Metropolitan Area became less monocentric (although commuting flows to Barcelonès were still the highest). Reverse commuting (from Barcelonès to the surrounding *comarcas*) and cross-commuting (flows from one *comarca* on the outskirts of Barcelona to another) increased dramatically in the 1986-1991 period. In

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Barcelona, Girona, Lleida and Tarragona.

contrast, commuting increased around the other three provincial capitals but its pattern continued to be mainly monocentric[3].

Most *comarcas* away from metropolitan areas had increasingly negative commuting balances in 1991, and as many of them were specialised in sectors with weak growth potential, mostly agriculture, also lost both population and workers. Surprisingly, four *comarcas* became secondary attraction poles, in spite of their relatively peripheral location and small population: these were Alt Camp, Alt Penedès, Segarra and Vall d'Aran. This last *comarca* is a popular mountain resort, while the other three have high levels of industrial concentration.

These trends consolidated in the 1991-1996 period: throughout Catalonia commuting had increased by 1996: 20.15% of Catalan workers were inter-*comarca* commuters, with an additional 21.71% commuting between different municipalities inside the same *comarca* (intra-*comarca* commuters). The average inter-*comarca* commute increased to 32.54 kilometres, flows between adjacent *comarcas* decreased to 85%, and the provincial capitals became the destination of less than half of all inter-*comarca* commuters (48%).

Barcelonès not only lost population in the 1991-1996 period, but resident workers as well. In 1991, 855,530 workers lived in Barcelonès, but by 1996 this figure had fallen to 738,197. In spite of this, the positive commuting balance of Barcelona *comarca* increased from 5.67% of its resident workers in 1991 (48,508 workers) to 8.19% in 1996 (59,859

[3] These patterns are similar to those found by Van der Laan (1998) in the Randstad region (Netherlands): Amsterdam metropolitan area is becoming more multicentred,

workers). This means that workers increasingly changed their residences from Barcelonès to other *comarcas*, but jobs were slower to do so. Population growth in both Gironès and Segrià came to an end: in 1996 both population and resident workers showed no increase over 1991 levels. Their commuting balance also remained constant, although their proportions of inter-*comarca* commuting and their aperture indexes increased[4]. In contrast, in Tarragonès, population and resident workers increased, though its commuting balance remained at 1991 levels. Commuting flows from the surrounding *comarcas* of Baix Camp, Baix Penedès and Priorat to Tarragonès increased over the period.

Inter-*comarca* commuting seems to be mostly related to *comarcas'* sectoral specialisation (see Artís *et al*, 1998a, 1998b). In contrast, intra-*comarca* commuting depends on the *comarca*'s urban structure: *comarcas* with higher intra-*comarca* commuting are those with a homogeneous urban network, in which no one city has an overwhelmingly dominant role (for example, the central, industrial *comarcas* of Anoia, Bages and Osona), while *comarcas* with lower intra-*comarca* commuting either have one city that takes the leading role (for example, Barcelona in the Barcelonès *comarca*) or are too scarcely populated to generate scale or scope economies that might keep resident workers inside the *comarca* (like most inland agricultural *comarcas*).

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while other smaller metropolitan areas (like Rotterdam or Eindhoven) are still mostly monocentric.

[4] Is this a sign that they are following the same evolution as Barcelonès? We do not have enough information to answer this question yet. However, the high-speed rail line (Madrid-Zaragoza-Lleida-Barcelona-Girona-France) is expected to be ready in 2004, and to judge from the effect of the Madrid-Seville line on commuting in Madrid it may have a major influence on commuting patterns,.

4.- Factors determining inter-*comarca* commuting flows: a preliminary evaluation of their evolution in the 1986-1996 period

The descriptive analysis of commuting in Catalonia shows two different kinds of zone: some *comarcas* can be considered economic centres, with a high job-density and positive commuting balance (meaning that there are more jobs than resident workers), while other *comarcas* can be described as residential, with a large proportion of their resident workers holding jobs outside the *comarca*. Although many *comarcas* could be considered "intermediate" cases, all can be broadly included in one of the patterns mentioned.

Our aim is to specify and estimate a model for inter-*comarca* commuting in Catalonia. The model should cast light on the attributes that make a *comarca* a preferred destination for workers, or alternatively, the characteristics that make it a better residential choice.

The theoretical starting point for our model is the standard urban model and its derivatives (as discussed in section 2). The standard urban model addresses two main subjects: residential location decision, and workplace decision. The simplest versions of the model consider that these decisions depend only on *wages* (workplace decision), *land price* (residential decision) and *distance* (both). However, in an empirical specification other variables should also be considered, such as *amenities* or *congestion* (which influence residential decision) or the *economic structure* of *comarcas* (which influences the workplace decision).

The explanatory variables should be able to capture different features from origin (i) and destination (j) *comarcas.* First, we should consider amenities, or variables that make i an attractive place to live. Then we should consider labour market variables from j, as they will explain j's capacity to attract workers from i. This specification has been used by Merriman and Hellerstein (1994) in a study of commuting in Tokyo.

However, in section 3 we saw that some workers live in j, while most of the resident workers in i do not commute outside the *comarca* where they live; so the model described above raises two important questions:

a) Why does a worker decide to commute if he might be able to find a job in his residence *comarca*?
b) Once the worker has found a job in a different *comarca*: why does he continue to commute instead of moving to the *comarca* where he actually works?

An intuitive answer to these questions would be: "He commutes because the destination labour market is more attractive than that of the origin. And he does not move because living conditions are better in his residence *comarca*."[5]

[5] An alternative suggestion would be that workers who decentralise (or change their residence *comarca*) are not interested in the labour market of the *comarca* they are going to live in, as they do not plan to change their jobs. This would be an implicit recognition of the fact that the labour market in the origin *comarca* is less attractive than the labour market in the destination *comarca*, as they do not expect to find a better job closer to their place of residence. Thus, this behaviour is not incompatible with our reasoning.

This would oblige us to reformulate our model: now the worker compares the labour market and living conditions of the two areas before making his choice. So now we have four sets of explicative variables, which are[6]:

L_i: labour market conditions in the residence *comarca*.
L_j: labour market conditions in the destination *comarca*
H_i: quality of life conditions in the origin *comarca*.
H_j: quality of life conditions in the destination *comarca*.

How do we include these four sets of variables in our model? An obvious choice would be the following:

$$C_{ij} = f\,(\beta_0 + \beta_1 L_i + \beta_2 L_j + \beta_3 H_i + \beta_4 H_j + u_{ij}), \qquad (1)$$

where C_{ij} is the commuting flow from *comarca i* to *comarca j*.

In this model we could reasonably expect that $\beta_1 \neq \beta_2$ and $\beta_3 \neq \beta_4$. This means that the same variables would have different effects if they belong to the origin or destination *comarca*. According to Gabriel *et al* (1987), this would mean that workers have a different level of information about each zone. This could be accepted in a migration model, where the individuals move over long distances (see Gabriel *et al* (1987, 1993)), but would be less realistic in a region like Catalonia (as it is a NUTS-II level region, we can assume that workers living and working in the region are well informed about the region's internal labour market, especially if the

[6] In order to test the existence of spatial effects (this is, a third *comarca* different from *i* and *j* having influence in the $i \rightarrow j$ commuting flow), we implemented Moran's I test for our model. The test cannot reject the null hypothesis (no spatial effects).

worker travels daily between the two *comarcas*). Therefore, we assume that workers have the same information about origin and destination *comarcas*, so they only have to compare the variables. Our model would then take the following form, in order to allow a direct comparison of variables:

$$C_{ij} = g\,(\beta_0 + \beta_1\,(L_j\,/\,L_i) + \beta_2\,(H_j\,/\,H_i) + \beta_3\,A_{ij} + u_{ij}), \qquad (2)$$

where A_{ij} is a vector of variables that measures the accessibility level (ease or difficulty of commuting) between *comarcas* i and j.

The functional form selected is the logistic curve: if we use each pair of *comarcas* as a case, we can use the ratio:

$$C_{ij} = \frac{\text{Number of } i \rightarrow j \text{ commuters}}{\text{Total workers living in } i}$$

as our dependent variable. This variable will always take a value between 0 and 1, as it is the sum of N individual choices made by workers living in the origin *comarca*: each individual choice will take a value of 1 if the worker decides to commute between i and j and will equal 0 otherwise. Our aggregate variable C_{ij} will equal 1 if all workers living in *comarca* i out-commute to j. $C_{ij} = 0$ if there is no commuting between i and j, and $0 < C_{ij} < 1$ for any amount of realistic commuting between i and j. A grouped data logit model is an adequate specification for such data[7].

[7] Alternative models were tried, like a linear model, a probit model or an attraction model (Haag, 1986, 1989), but the logit specification showed the best fit.

Variables considered as potential integrants of vectors *H*, *L* and *A* are listed in table 3.

4.1.- The H vector represents the features that make a zone a pleasant residential area. It should include variables related to quality of life in *comarcas.* Alonso's model gives us two obvious choices to include: housing prices, and home sizes. Other amenities that could influence residential decisions should also be considered: some authors have tried to use a full set of amenity variables, including climatic, cultural, crime and urban structure variables. If correctly specified, this approach is appealing because these variables may provide information on what families are looking for when choosing a place to live, but it also has some important problems:

* To capture all the different kinds of amenities we will need a large set of variables. This decreases the degrees of freedom in the model.
* Variables are likely to be correlated; this will cause problems of multicollinearity.
* The choice of amenity variables is always somewhat arbitrary (see Knapp and Graves, 1989).

Other studies have tried to capture the effect of amenities using only one or two relevant variables, but this strategy is bound to cause a substantial loss of information in the model.

In an earlier version of this paper (Artís *et al*, 1998*b*), we chose a third option: the use of a *Synthetic quality of life index for Catalan comarcas* (Quadrado, 1996). The problem with this index is that it was calculated only for 1991, and we did not have sufficient information to replicate it for 1996.

Another difficulty is the fact that most facilities contributing to welfare (such as hospitals, schools or cinemas) can be used by residents of all *comarcas*, not only by residents in the *comarca* where the facility is built (although the penalty for out-*comarca* users is a longer trip). So we calculated a *perificity index* (Keeble *et al*, 1988), which takes into account facilities both in the *comarca* and in other *comarcas* (weighted by distance). As this index had a correlation of 0.95 with the *population* variable (due to the high concentration of both population and infrastructures in Barcelona Metropolitan Area), we used the *population* variable instead.

To test the possibility of saturation of the amenities, we also calculated *per capita* variables. However, as they induced multicollinearity in the model, the coefficients are not displayed.

Per capita rent level was not included in this vector, as Quadrado (1996) has shown it is not a good proxy for quality of life, and it would cause strong multicollinearity due to its correlation with wages.

Our main problem was the lack of information about housing prices: no official source calculates this information for the 41 Catalan *comarcas*. The only information available is a study commissioned by "Departament de Política Territorial i Obres Públiques" (Infrastructures Department of the Catalan regional government), which calculates home prices (per m^2) for main cities in 15 *comarcas* in 1986, 19 *comarcas* in 1991 and 22 *comarcas* in 1996 (see map 1 and table 1). If we want our comparison of the influence of explicative variables to be unbiased, we have to use the same *comarcas* for all the regressions; otherwise we will be unable to discern the effect of trend changes from the effect caused by the addition of new cases. If we used only the 15 *comarcas* for which we have data in 1986, 1991 and 1996, the sample would be too small and we would face serious multicolinearity problems. So we decided to concentrate on 1991 and 1996, and include in our regression the 19 *comarcas* with known housing prices for these years. As these 19 *comarcas* accounted for 87% of total inter-*comarca* commuting in 1991 and 86% in 1996, we dropped the rest from our model. Our model had 342 cases, each one being a pair of the 19 *comarcas* for which we had information about home prices in 1991 and 1996 (see map 1). The model was estimated for both years.

Another important variable is the availability of residential land and housing. We proxied it by measuring the proportion of large homes (> $150m^2$) in the *comarca*. Some families (described by Simpson as "land-hungry") may be able to buy a home in "central" comarcas, in spite of higher prices there. Nevertheless, they value residential space over accessibility, so they may prefer to buy a larger home away from the centre and commute[8].

The last variable included in the H vector was the migration balance (in percentage of total resident population), as *comarcas* with a better quality of life are assumed to attract migrants from other zones. We used a "revealed preference" approach: we assumed that migrants move to the

[8] Home sizes are calculated in the Housing Census, which is conducted every 10 years. The latest one is from 1991, so we have had to use data from it for 1991 and 1996 regressions. This may cause a certain distortion in the results from the 1996 regression.

comarcas they consider more desirable to live in. Due to the possibility of simultaneity between *migration* and *commuting*, we considered different specifications of the model (see table 4 and section 5).

4.2.- The L vector: This vector of variables captures labour market conditions. We must first include a wages variable: if wages are higher in some zones than the rest, workers will be tempted to quit their jobs to find new ones in zones with higher wages, provided the wage increase compensates for the increased commuting time and costs. We used the mean collection of personal income tax (*Impuesto sobre la Renta de las Personas Físicas* or *IRPF*) for each *comarca*, as this tax charges mainly wages. A second obvious variable is the unemployment rate: theory would lead us to expect that commuting flows would be in the direction high unemployment → low unemployment *comarcas*.

The composition of labour force by professional categories or sectors seemed to have no effect on the aggregate flows of inter-*comarca* commuting (although the professional category of an individual worker and the sector in which he works has a strong influence on his commuting decision: see Artís *et al*, 1998*a*, 2000).

The *population* variable (included in the *H* vector) can be also considered as a proxy for agglomeration economies and the ease or difficulty of finding a job in the *comarca*.

4.3.- The A vector: This vector measures accessibility between each pair of *comarcas*. It includes distance and a dummy variable that equals 1 if the two *comarcas* have a common boundary. In previous estimations, we included three dummy variables that equalled 1 if the *comarcas* are connected by *metro* (tube), *RENFE* (shuttle services of national railways) or *Ferrocarrils de la Generalitat* (regional railways). Merriman and Hellerstein (1994) and Crampton (1990) outline the importance of rail transport for commuting flows. However, these rail dummy variables proved statistically insignificant, so their estimates are not displayed.

4.4.- Variables chosen for the model

Our model included the following explanatory variables:

- H vector:

Price m^2 = Housing price$_j$ / Housing price$_i$
Homes > 150 = % Homes > 150m^2 $_j$ / % Homes > 150m^2 $_i$
Population = Population $_j$ / Population $_i$
Real State tax = Real state tax (per m^2) $_j$ / Real state tax (per m^2) $_i$

Net migration* = Net migration$_j$ - Net migration$_i$ (both in % of residents)

In order to avoid potential simultaneity problems, the *Net migration* variable was included in an alternative specification of the model. This alternative model was estimated using specific econometric methods to deal with simultaneity (Instrumental Variables; see table 4).

- L vector:

Inc Tax = Average personal income tax$_j$ / Average personal income tax$_i$
Unemployment = % Unemployment $_j$ / % Unemployment $_i$

- A vector:

Distance = Distance between *comarcas*
Contact = *Dummy* for pairs of *comarcas* sharing boundaries

The results are consistent with the descriptive analysis discussed in section 2 and with the descriptive analysis of explanatory variables for 1986, 1991 and 1996, so we considered them to be an adequate approximation of the evolution of territorial determinants of commuting in Catalonia in the 1986-1996 period.

5.- The place-to-place commuting model: estimation and discussion

Table 4 shows the main results of the logit models for 1991 and 1996. The first model obtained a good fit for 1991 (adjusted R^2: 0.76), but not for 1996 (adjusted R^2: 0.44), while the alternative model (including the *migration balance* variable) raised the 1996 fit to 0.68 (see table 4). No important correlation between independent variables (or other signs of multicolinearity) was detected (see table 4)[9]. T-tests rejected the null hypothesis of coefficient stability between 1991 and 1996 for the *Home price per* m^2*, % of dwellings >* $150m^2$ and *Unemployment* variables (whose change between 1991 and 1996 was strong enough for the F-test to reject the null hypothesis of joint stability of the coefficients).

The main results (with variables grouped in vectors H, L and A) were the following:

[9] Equation (3) was estimated independently for 1991 and 1996. We also tried to estimate both years jointly (in a Seemingly Unrelated Equations framework) but there was no gain in efficiency.

- **Price_m^2** (=Average housing price per m^2 in destination / Average housing price per m^2 in origin). We expect that *comarcas* with a higher job density are more crowded. Housing faces strong competition from alternative uses of land, such as industry, commerce and business. Both these facts increase housing prices compared with other *comarcas*, as deduced from the Residential Location model. Our estimates confirmed the model's predictions: this variable was positive for 1991 and even more so for 1996, suggesting that workers preferred to live in *comarcas* where they can find cheaper homes, even if this forces them to longer commutes. This trend became stronger due to the increase of residential prices in capitals and cities closer to them ("suburban first ring").

- **Homes>150** (= % of homes larger than 150 m^2 in destination / % of homes larger than 150 m^2 in origin). This variable proxies the mean size of homes in each *comarca*. Central *comarcas,* with a high density of jobs, tended to present congestion problems and scarcity of residential land, as it has to compete with other land uses. Alonso's model predicts that the mean size of homes will decrease as we approach the central business district, forming a density gradient. Our estimates confirmed this prediction for 1991: the variable's coefficient was negative, meaning that commuting takes the larger homes $\rightarrow$ smaller homes *comarcas* direction. We were even able to separate families into "access-hungry" – those which place a high value in their time and prefer to live in smaller homes, closer to their jobs, and "land-hungry" – those willing to spend more time commuting in exchange for having a larger home (Simpson, 1992). "Land-hungry" households are more likely to be affected by this variable. In 1996, the variable was also negative, but it did not seem to be significant. This might be caused by the lack of up-to date data (see note 6).

- **Population** (= Population $_j$ / Population $_i$). This variable proxies the higher density of jobs in cities and metropolitan areas, which means that it is easier to find a job in a high population area than in a rural or low population area. It also had an important relation with *infrastructure* and *amenities*, as its correlation with an *amenity accessibility index* is 0.95. The variable was not significant for 1991, but it was positive for 1996, meaning that commuting flows take the low population *comarcas* → high population *comarcas* direction.

- **IRPF** (= Average *IRPF* tax collection in destination / average *IRPF* tax collection in origin). The standard residential location model postulates that firms located at the central business district have to pay higher wages than decentralised firms. If they did not, workers could increase their utility by seeking a job in a firm closer to their home. Firms in the central business district have to compensate their workers for their longer commutes. If the model holds, this variable should have a positive sign and a large explanatory power in our equation.

  Our results confirm the prediction: this variable (a proxy for average wages, as this tax charges mostly wage earners) was positive and highly significant. Thus, workers are willing to commute to *comarcas* with higher wages. In 1996, this variable was positive but not significant. This was probably due to differences in the economic situation in the two years: 1991 was the peak of an expansive cycle, which in Catalonia was especially intense due to the 1992 Olympic Games, held in Barcelona. The recession that came after the Games was equally strong, so in 1996 unemployment was much higher, and economic activity was still weak.

- **Unemployment** (= % Unemployment $_j$ / % Unemployment $_i$). This variable was negative in both years, meaning that commuting flows followed the high unemployment *comarcas* → low unemployment *comarcas* direction. The variable was not significant in 1991, but it had become significant by 1996. As in the case of the *IRPF* variable, the cause was the difference in economic situation of the two years: in 1991, the unemployment rate in Catalonia was 12.2% (low by Spanish standards), so it was easier for workers to find a job closer to their residence. In contrast, the unemployment rate in 1996 was 18.9%, so workers looking for a job had to extend their search area, and were more willing to accept jobs which implied longer commutes than they had been in 1991.

- **The accessibility (A) vector**: This vector contains a set of variables used to measure the feasibility or difficulty of commuting between each pair of *comarcas*. We should expect better communications and shorter travel times to result in higher commuting flows. The ideal variable would have been average commuting time between *comarcas*, but unfortunately this was not available, so we had to use other variables to proxy it.

The most important was **distance**: as expected, it had a negative coefficient and it was the variable that obtained the greatest significance in our model. its sign was reinforced by the positive coefficient of the **contact** variable (a dummy that takes a value of 1 if both *comarcas* share boundaries and 0 otherwise). Variables relative to the existence of *public transport* between *comarcas* were not significant, so their coefficients are not displayed.

- **Net migration**: Table 4 shows that the model's fit was much better in 1991 than in 1996. This is probably because certain explanatory variables (in particular *migration,* residence change) affected commuting flows in 1996 but not in 1991. Suburbanisation in Catalonia is mostly caused by families leaving the Municipal Area of Barcelona, but since 1991 this phenomenon has extended to the rest of municipalities in the Barcelonès *comarca*. Until 1991, families who left Barcelona relocated mostly in other municipalities in the Barcelonès, but, as land prices in these cities are coming closer to land prices in Barcelona, they have also started to lose population. Most of these workers who suburbanise keep their jobs in Barcelonès *comarca*, so this situation leads to increasing commuting flows. The sign of this variable was negative, and was significant for 1996 (see table 4, model *b*), but not for 1991, which confirmed our hypothesis (and also the "jobs follow people" hypothesis).

The problem with this variable is its potential simultaneity with *commuting*, causing a *simultaneity bias* in the estimated coefficients, as the Hausman test confirms for 1996 (table 4, model *b1*). In the 1991 equation, the problem was not important: *migration* was not significant, the coefficients of the rest of variables hardly changed at all, the adjusted R^2 did not increase and the Hausman test was not significant. In 1996, the variable was highly significant, and its inclusion increased the adjusted R^2 from 0.44 to 0.68. The coefficients of the rest of variables when *migration* is included were very different from those in the original model. To avoid the simultaneity bias, we decided to use an *instrumental variable* approach. Its coefficients are shown in table 4 (model *b2*).

In conclusion, *migration* had a major influence in the 1996 inter-*comarca* commuting flows, but not in 1991: In 1991 the Hausman test was not significant, and coefficients ignoring simultaneity (model *b1*) were the same as coefficients in the *instrumental variables* estimation (model *b2*). In contrast, the *instrumental variables* approach (model *b2*) was better for 1996.

* **Real State Tax** (= Real state tax (per m^2)$_j$ / Real state tax (per m^2)$_i$)
Some authors (see, for example, Clark and Hunter, 1992; Fox *et al*, 1989 or Roback, 1982) suggest that high taxes and high crime rates in central cities induce the suburbanisation of high and middle-income families. To test this hypothesis, we included the *Impuesto de Bienes Inmuebles (IBI)*[10], which is a real state tax collected by municipalities, as an explanatory variable (see table 4, model *c*). This variable was significant for 1996, but its sign was contrary to expectations: suburban *comarcas* seemed to have higher property taxes than central *comarcas*. Probably, the explanation is the low fiscal autonomy of Spanish municipal authorities, as income tax rates

[10] Unfortunately, no figures for crime rates are available at *comarca* level.

are decided at regional or national levels. This means that families cannot expect large tax savings by changing their residence to another municipality inside the same region.

6.- Conclusions and future research lines

We set out to analyse internal commuting in a NUTS-II level region (choosing Catalonia as our empirical subject) and to validate (or reject) the most important predictions of the standard residential location model for this region. To do so, we proposed an econometric model which was estimated in a logit framework.

Even though population in Catalonia is highly centralised (Barcelonès and the four *comarcas* that surround it account for two-thirds of the Catalan population), and 63% of Catalan workers do not commute away form their residence municipality, there is a trend towards an increase in both suburbanisation and commuting times.

Workers who decide to commute are willing to accept a loss of utility (in the form of longer commutes), in exchange for a better quality of life and larger or cheaper homes. Some workers are attracted by higher wages in other *comarcas*, but they do not wish to change their residence *comarca*. All these facts are predicted in the standard urban model, so the behaviour of Catalan workers and families is well reflected in this model.

We have also shown that commuting does not appear homogeneously: it concentrates in certain zones, activity branches (those with larger firms and factories) and professional categories (mostly, directives and professionals).

The results of our study show that the suburbanisation phenomenon strongly affected Catalonia through the 1986-1996 decade. This trend is common in most developed countries (Palumbo *et al*, 1987 Greenwood and Stock, 1988; Margo, 1990), though it reached Spain later than other European countries or the United States. However, its patterns are largely the same as in the rest of Europe (see Van der Laan, 1998, or Rouwendal, 1999).

The analysis of aggregate commuting flows allows us to detect the variables that commuters consider when choosing a residence zone and why they keep a job far away from the zone they have chosen to live in. Congestion and high housing prices in the capitals have induced many workers and families to suburbanise, and, when doing so, they have opted for *comarcas* with lower housing prices and larger dwellings. As transport networks extend and improve, suburbanisation is bound to expand to *comarcas* further away from the capitals, while *comarcas* close to the provincial capitals – which some time previously were peripheral – become a part of the centre.

The effect of the economic cycle is seen in the *Income tax* and *Unemployment rate* variables, which behave differently in a year of expansion (1991) than in one of recession (1996). The hypothesis of fiscal induced suburbanisation does not seem to hold for the Spanish case. There is also a substantial difference in the influence of *migration flows* (suburbanisation-induced) between 1991 and 1996.

We believe this model can be used to estimate and analyse commuting in other NUTS-III level regions, especially in those similar to Catalonia in extension and population (but also in those with a similar economic structure, income or welfare level). Previous studies (such as Merriman and Hellerstein (1994) for Tokyo Metropolitan Area; Casado (1997) for the Spanish region of Valencia; Van der Laan (1998) for the Dutch region of the Randstadt or Rouwendal (1999) for Holland) lead us to believe that the results of the model would be largely similar to ours.

An interesting extension of our model would be the joint estimation of migration and commuting flows in a simultaneous equation framework.

REFERENCES

Abdel-Rahman, Hesham and Fujita, Masahisa: "Specialisation and diversification in a system of cities". *Journal of Urban Economics*, 33, 1993.

Alonso, William: "A theory of urban land market". *Papers and proceedings of the Regional Science Association*, 6, 1960.

Artís, Manuel; Romaní, Javier and Suriñach, Jordi: "Análisis de los factores determinantes de la movilidad territorial en Cataluña, 1986-1991". Documents de treball de la divisió de Ciències Jurídiques, Econòmiques i Socials. Universitat de Barcelona, Mar. 1998*a*.

Artís, Manuel; Romaní, Javier and Suriñach, Jordi: "Commuting in Catalonia: estimates from a place-to-place model" 38 ERSA Congress, Vienna, Aug. 1998*b*.

Artís, Manuel; Romaní, Javier and Suriñach, Jordi: "Determinants of individual commuting in Catalonia, 1986-1991: Theory and empirical evidence". *Urban Studies* (expected Aug. 2000).

Asensio, Javier: "Descentralización residential y elección de modo de transporte". II Encuentro de Economía Aplicada, Zaragoza, Jun. 1999.

Casado, José M.: "Spatial labour market areas in Spain: a case study". 37º ERSA Congress, Rome, 1997.

Clark, David and Cosgrove, James: "Amenities versus market opportunities: choosing the optimal distance to move". *Journal of Regional Science*, Aug. 1991.

Clark, David and Hunter, William: "The impact of economic opportunity, ammenities and fiscal factors on age-specific migration rates". *Journal of Regional Science*, 31, Ago. 1992, Pp 349-365.

Costa, A. and Rovira, C.: "La distribució territorial de la renda i el patrimoni a Catalunya", in *La societat Catalana*, Institut d'Estadística de Catalunya, Barcelona, 1998.

Crampton, G. R.: "Commuting between local authorities in England and Wales: Econometric evidence from the 1981 census". *Journal of Urban Economics*, 28, 1990.

Fox, F.; Herzog, Henry Jr. and Schlottman, Alan: "Metropolitan fiscal structure and migration". *Journal of Regional Science*, 29, Nov. 1989, Pp 523-536.

Gabriel, Stuart; Justman, Moshe and Levy, Amnon "Place to place migration in Israel: Estimates of a logistic model" *Regional science and Urban Economics*, April, 1987.

Gabriel, Stuart; Shack-Marquez, Janice and Wascher, William: "Does migration arbitrage regional labour market differentials?". *Regional Science and Urban Economics*, 23, Abril 1993.

García, Dolores: "Sustainable urban growth in the region of Barcelona: an estimation through contingent valuation and contingent ranking". II Encuentro de Economía Aplicada, Zaragoza, Jun. 1999.

Greenwood, Michael and Hunt, Gary: "Jobs versus amenities in the analysis of metropolitan migration". *Journal of Urban Economics*, 25, 1989.

Greenwood, Michael and Stock, Richard: "Patterns of change in the intrametropolitan location of population, jobs and housing: 1950 to 1980". *Journal of Urban Economics, num. 28*, 1990.

Haag, G.: *Dinamic decision theory and applications to urban and regional topics*. Kluwer Academic Corp., Dordrecht, 1989.

Haag, G. and Weidlich, W.: "A dynamic migration theory and its evaluations for concrete systems". *Regional Science and Urban Economics*, Feb. 1986.

Keeble, D., Offord, J. and Wacker, F.: "Peripheral regions for a Community of twelve member states" European Commission paper, 1988.

Koide, Hiroyuki: "General equilibrium analysis of urban spatial structure: the port-city model reconsidered" *Journal of Regional Science*, Aug. 1990.

Margo, Robert: "Explaining the postwar suburbanization of population in the United States: the role of income". *Journal of Urban Economics*, 31, 1992.

Mendizábal, E. and Sánchez, E.: "La mobilitat habitual de la població a Catalunya", in *La societat Catalana*, Institut d'Estadística de Catalunya, Barcelona, 1998.

Merriman, David and Hellerstein, Daniel: "Compensation for commutes in the land and labour markets: some evidence from the Tokyo metropolitan area". *Journal of Regional Science*, 3, 1994.

Módenes, J.A. and Pascual, J.: "Les migracions interiors a Catalunya. Intensitat, selectivitat i estructura espacial dels fluxos migratoris", in *La societat Catalana*, Institut d'Estadística de Catalunya, Barcelona, 1998.

Palacio, G. (dir.): *Cohesió, centralitat i cohesió iterativa a Catalunya: 1981-1986-1991-avanç 1996*. Departament d'Obres Públiques, Generalitat de Catalunya, Barcelona, 1998.

Nakagome, Masaki: "Competitive and imperfectly competitive labor markets in urban areas". *Journal of Regional Science*, Mayo, 1991, Pp 161-170.

Palumbo, George; Sacks, Seymour and Wasylenko, Michael: "Population decentralization within metropolitan areas: 1970-1980". *Journal of Urban Economics*, 27, 1990.

Roback, Jennifer. Wages, Rents, and the Quality of Life.. *Journal of Political Economy*. Vol. 90 (6). p 1257-78. December 1982.

Romaní, Javier: "A first approximation to the evolution of commuting in catalonia, 1986-1996"; 39th ERSA Congress, Dublin, 1999.

Rouwendal, Jan: "Spatial job search and commuting distancies". *Regional Science and Urban Economics*, 29, Pp 491-517, 1999.

Sau, Elisabet: "La evolución del sistema urbano de Catalunya entre 1950 y 1991: una aproximación según el modelo de Peter Hall". *Revista de Estudios Regionales*, 35, 1993.
Simpson, Wayne: *Urban structure and the labour market*. Clarendon Press, Oxford, 1992.
Thurston, Lawrence and Yezer, Anthony: "Causality in the suburbanization of population and employment". *Journal of Urban Economics*, Jan. 1994.
Turnbull, Geoffrey K.: "Location, housing and leisure demand under local employment". *Land Economics*, 68, Feb. 1992, Pp 62-71.
Van der Laan, Lambert: "Changing urban systems: an empirical analysys at two spatial levels". *Regional Studies*, May 1998.
White, Michelle: "Location choice and commuting behaviour in cities with decentralized employment". *Journal of Urban Economics*, 24, 1988.
Zheng, Xiao-Ping: "The spatial structure of hierarchical inter-urban systems: equilibrium and optimum" *Journal of Regional Science*, 3, 1990.

APPENDIX: MAPS, TABLES AND FIGURES

FIGURE 1: LOCATION OF CATALONIA

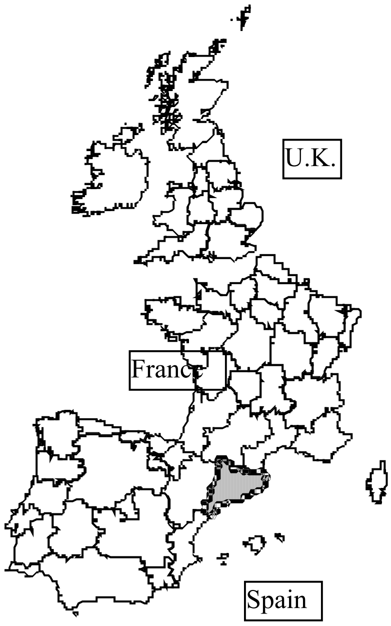
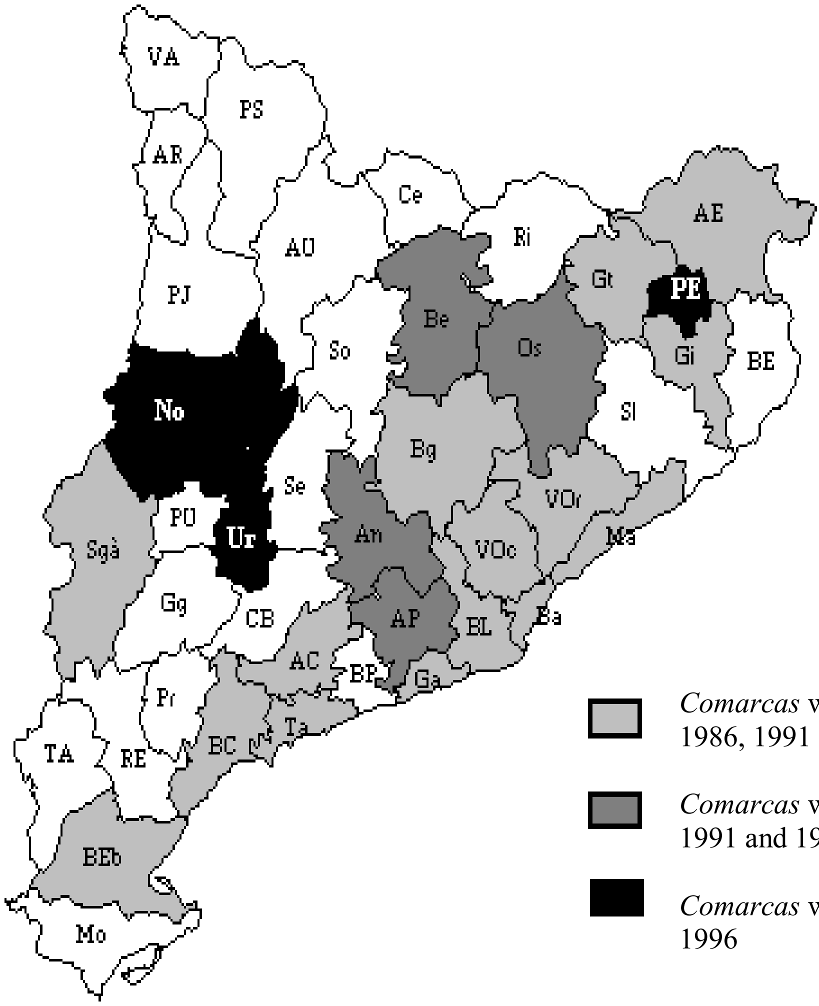


FIGURE 2: COMARCAL DIVISION OF CATALONIA AND *COMARCAS* USED IN THE LOGIT ESTIMATION



Comarcas with known housing prices in 1986, 1991 and 1996

Comarcas with known housing prices in 1991 and 1996

Comarcas with known housing prices in 1996

TABLE 1: *COMARCAS'* COMMUTING MAIN FIGURES

COMARCA	INTER-*COMARCA* COMMUTING			INTER-*COMARCA* COMMUTING (%)*			COMMUTING BALANCE			COMMUTING BALANCE (%)			INTRA-*COMARCA* COMMUTING			INTRA-*COMARCA* COMMUTING (%)**			APPERTURE INDEX		
	86	91	96	86	91	96	86	91	96	86	91	96	86	91	96	86	91	96	86	91	96
Alt Camp (AC)	1035	1502	2191	9.26	11.74	17.71	85	612	201	0.25	1.80	0.58	1050	1702	1818	9.40	13.31	14.70	19.29	28.27	37.05
Alt Empordà (AE)	1092	2245	3202	3.70	6.41	8.88	176	-701	-1018	0.21	-0.77	-1.09	5316	8640	9943	18.00	24.67	27.57	7.99	10.82	14.93
Alt Penedès (AP)	2085	3179	4613	9.83	11.93	16.45	-227	402	364	-0.34	0.58	0.50	3829	6745	8057	18.04	25.31	28.73	18.58	25.37	34.19
Alt Urgell (AU)	190	417	526	2.78	5.57	7.49	110	-93	-143	0.58	-0.49	-0.75	670	857	945	9.80	11.44	13.46	7.17	9.89	12.95
Alta Ribagorça (AR)	62	225	270	6.18	17.87	20.07	-19	-180	-205	-0.52	-5.12	-5.79	41	95	137	4.08	7.55	10.19	10.46	21.45	24.91
Anoia (An)	1395	2919	4615	5.41	9.28	14.31	496	-910	-1911	0.62	-1.10	-2.20	7395	9916	10500	28.65	31.54	32.55	12.73	15.67	22.69
Bages (Bg)	2782	5153	5927	5.86	9.26	10.91	-996	-2410	-2095	-0.66	-1.58	-1.37	9369	13772	15852	19.73	24.76	29.19	9.62	14.19	17.97
Baix Camp (BC)	5738	9596	12570	15.32	20.45	25.12	-2385	-5061	-6692	-1.93	-3.85	-4.76	3444	4762	5931	9.19	10.15	11.85	24.27	30.12	36.87
Baix Ebre (BEb)	1131	2122	2440	5.67	9.42	11.00	-33	-206	-381	-0.05	-0.32	-0.58	2312	3671	3755	11.58	16.29	16.93	11.17	17.92	20.28
Baix Empordà (BE)	1998	3150	4895	7.01	9.21	13.30	-832	-1228	-2433	-0.99	-1.37	-2.53	5069	7568	9293	17.79	22.13	25.24	11.11	14.83	19.98
Baix Llobregat (BL)	56453	82716	90176	35.21	37.22	38.62	-23829	-30474	-21607	-4.08	-4.99	-3.36	33876	50080	60126	21.13	22.53	25.75	55.55	60.73	67.99
Baix Penedès (BP)	1113	2703	5241	10.57	19.25	30.17	307	-894	-2614	0.92	-2.35	-5.50	1698	2609	3260	16.12	18.58	18.76	24.05	32.14	45.29
Barcelonès (BA)	67442	104197	122263	9.58	12.18	16.56	32116	51477	60108	1.35	2.24	2.82	112040	147956	130941	15.91	17.29	17.74	23.71	30.38	41.27
Berguedà (Be)	710	1592	2105	5.36	11.75	16.37	59	-620	-1188	0.15	-1.59	-3.09	2902	2694	2909	21.89	19.89	22.62	11.16	18.93	23.50
Cerdanya (Ce)	230	427	676	5.54	8.65	13.13	-6	-101	-305	-0.05	-0.81	-2.39	333	632	746	8.02	12.80	14.49	10.94	15.25	20.33
Conca de Barberà (CB)	607	1152	1303	9.69	17.63	20.23	-270	-655	-419	-1.47	-3.64	-2.29	636	710	948	10.15	10.86	14.72	15.07	25.23	33.95
Garraf (Ga)	2690	4752	9233	12.92	17.46	28.08	-1059	-2339	-6237	-1.47	-3.04	-6.90	2961	4543	5896	14.22	16.69	17.93	20.76	26.33	37.19
Garrigues (Gg)	796	1508	1724	11.86	22.10	26.46	-580	-1114	-1230	-2.87	-5.73	-6.38	236	422	423	3.52	6.19	6.49	15.08	27.88	34.04
Garrotxa (Gt)	906	1361	1752	5.10	7.23	9.36	-364	-524	-414	-0.80	-1.14	-0.89	2936	3822	4555	16.53	20.30	24.35	8.15	11.67	16.52
Gironès (Gi)	3289	4681	7172	7.89	9.07	13.86	2445	3729	3229	2.00	2.96	2.50	10817	14963	16007	25.94	29.00	30.94	21.64	25.37	33.97
Maresme (Ma)	14694	25111	34377	17.11	23.18	29.54	-8235	-16389	-23493	-3.06	-5.59	-7.37	12870	20366	24141	14.99	18.80	20.74	24.64	31.24	38.89
Montsià (Mo)	960	2027	2202	5.73	10.65	11.70	-427	-892	-777	-0.79	-1.64	-1.42	1321	1718	2085	7.88	9.03	11.08	8.91	16.61	19.27
Noguera (No)	1195	2184	2828	10.49	17.53	22.96	-702	-1453	-1638	-1.96	-4.18	-4.76	785	1248	1506	6.89	10.02	12.23	14.82	23.40	32.62
Osona (Os)	2111	3265	4202	4.86	6.62	8.36	-764	-772	-1395	-0.66	-0.66	-1.13	11335	15264	17278	26.11	30.96	34.39	7.96	11.68	13.95
Pallars Jussà (PJ)	289	571	661	6.96	12.45	14.37	-138	-332	-415	-1.00	-2.58	-3.24	404	591	666	9.72	12.89	14.48	10.59	17.66	19.72
Pallars Sobirà (PS)	171	352	506	8.77	16.88	21.20	-116	-242	-363	-2.12	-4.47	-6.24	148	248	419	7.59	11.89	17.55	11.60	22.16	27.19
Pla d'Urgell (PU)	857	1580	2139	9.34	15.10	20.01	-132	-222	-429	-0.46	-0.77	-1.47	945	1613	1948	10.30	15.42	18.22	17.25	28.08	36.01
Pla de l'Estany (PE)	1013	1483	2114	12.66	17.59	22.29	-396	-438	-799	-1.85	-2.08	-3.35	2022	2295	2746	25.28	27.22	28.96	20.38	29.99	36.16
Priorat (Pr)	348	747	932	11.24	22.60	30.72	-200	-548	-718	-1.99	-5.78	-7.79	183	283	229	5.91	8.56	7.55	16.03	28.62	37.77
Ribera d'Ebre (RE)	461	930	899	6.78	12.31	12.74	189	-16	222	0.80	-0.07	0.99	1149	1565	1502	16.91	20.72	21.29	16.35	24.42	28.64
Ripollès (Ri)	598	1150	1408	6.01	10.51	13.51	-86	-586	-605	-0.30	-2.16	-2.29	1399	1841	2129	14.06	16.83	20.43	11.16	15.66	21.21
Segarra (Se)	595	917	1056	10.65	13.92	15.13	-130	537	1208	-0.76	3.15	6.94	419	794	898	7.50	12.05	12.86	18.97	35.99	47.56
Segrià (Sgà)	1333	3032	4212	2.67	5.04	7.02	847	620	589	0.53	0.38	0.36	3531	6554	7725	7.07	10.89	12.88	7.03	11.11	15.02
Selva (Sl)	3233	5795	8201	9.68	15.30	19.35	1005	-736	-1181	1.10	-0.75	-1.13	4009	5809	6895	12.01	15.33	16.27	22.38	28.65	35.91
Solsonès (So)	218	471	533	6.27	11.10	12.06	-79	-146	-82	-0.73	-1.35	-0.73	343	471	631	9.86	11.10	14.28	10.26	18.75	22.27
Tarragonès (Ta)	3495	6582	9341	7.89	11.63	15.09	3971	4242	4630	2.66	2.72	2.74	5266	8757	12071	11.89	15.47	19.50	24.75	30.76	37.67
Terra Alta (TA)	238	612	629	5.46	13.79	15.46	-174	-507	-469	-1.29	-3.92	-3.79	96	217	238	2.20	4.89	5.85	6.92	16.16	19.40
Urgell (Ur)	844	2084	2582	8.76	18.50	22.47	-157	-984	-1272	-0.52	-3.30	-4.21	642	1000	1213	6.66	8.88	10.55	15.89	28.27	33.86
Val d'Aran (VA)	35	156	245	1.56	5.91	7.81	62	72	-32	1.03	1.16	-0.45	293	408	742	13.05	15.46	23.65	5.88	14.55	14.60
Vallès Occidental (VOc)	30443	45435	54047	17.44	19.13	21.65	-4117	3555	9340	-0.66	0.55	1.36	27748	50787	65025	15.89	21.39	26.05	32.52	39.77	47.04
Vallès Oriental (VOr)	11644	19092	28130	15.31	18.63	25.36	4585	6527	2669	1.91	2.49	0.94	20774	32363	36362	27.31	31.59	32.78	36.65	43.64	53.13
Total Catalonia	226519	359173	444138	12.45	15.92	20.15	0	0	0	-	-	-	302612	440351	478491	16.64	19.52	21.71	24.91	31.85	40.30

*: % of workers in the *comarca* who commute to other *comarcas*.

**: % of workers in the *comarca* who commute between different municipalities in the same *comarca*.

Note: The difference between 100% and the sume of inter-*comarca* and intra-*comarca* commuting is due to the workers who live and work in the same municipality.

Source: Elaborated by the authors from Institut d'Estadística de Catalunya (IDESCAT) data

TABLE 2: *COMARCAS'* POPULATION AND RESIDENT WORKERS, 1986-1996

COMARCA	POPULATION			RESIDENT WORKERS		
	1986	1991	1996	1986	1991	1996
Alt Camp	33804	34016	34403	11172	12791	12370
Alt Empordà	85398	90755	93172	29541	35023	36068
Alt Penedès	67005	69863	73196	21220	26646	28047
Alt Urgell	18865	19010	19006	6837	7490	7021
Alta Ribagorça	3626	3514	3542	1004	1259	1345
Anoia	79594	82450	86964	25809	31443	32259
Bages	150421	152177	152586	47477	55627	54310
Baix Camp	123745	131599	140540	37460	46919	50037
Baix Ebre	64452	64645	65879	19963	22535	22182
Baix Empordà	83911	89930	95986	28488	34191	36813
Baix Llobregat	583354	610192	643621	160341	222242	233484
Baix Penedès	33211	38080	47550	10534	14039	17374
Barcelonès	2376600	2302137	2131378	704259	855530	738197
Berguedà	40677	38965	38389	13258	13547	12860
Cerdanya	12200	12396	12757	4151	4938	5149
Conca de Barberà	18404	18001	18285	6266	6535	6441
Garraf	71816	76915	90435	20819	27213	32884
Garrigues	20214	19429	19273	6712	6822	6515
Garrotxa	45368	46060	46708	17761	18828	18709
Gironès	122350	125875	129044	41700	51591	51732
Maresme	269502	293103	318891	85863	108314	116390
Montsià	54027	54307	54765	16755	19032	18824
Noguera	35847	34782	34390	11390	12458	12316
Osona	115258	117442	122923	43416	49302	50248
Pallars Jussà	13817	12860	12817	4155	4586	4599
Pallars Sobirà	5464	5418	5815	1949	2085	2387
Pla d'Urgell	28675	28802	29116	9171	10462	10690
Pla de l'Estany	21416	21072	23833	7999	8430	9482
Priorat	10051	9475	9212	3095	3305	3034
Ribera d'Ebre	23650	23055	22442	6795	7552	7054
Ripollès	28314	27167	26365	9947	10942	10422
Segarra	17104	17040	17407	5587	6588	6981
Segrià	158677	162904	162529	49942	60172	60000
Selva	91238	98255	104833	33384	37881	42386
Solsonès	10796	10792	11171	3478	4245	4419
Tarragonès	149090	155881	169016	44292	56594	61890
Terra Alta	13449	12945	12382	4362	4437	4068
Urgell	29964	29789	30181	9638	11264	11493
Val d'Aran	6034	6184	7130	2246	2639	3138
Vallès Occidental	620786	649699	685600	174572	237454	249627
Vallès Oriental	240464	262513	285129	76059	102463	110920
Total Cataluña	5978638	6059494	6088661	1818867	2255414	2204165

Source: Institut d'Estadística de Catalunya (IDESCAT)

TABLE 3: WEIGHTED AVERAGES OF VARIABLES

	1986-1996	1986	1991	1996
% Of commuting between *comarcas* with known housing prices in 1986	0.82	0.84	0.83	0.81
H VECTOR (Quality of life)				
Education index (destination)	5.66	5.69	5.41	5.83
Education index (origin)	5.73	5.78	5.52	5.86
Health index (destination)	2.46	2.16	3.46	1.81
Health index (origin)	2.22	1.95	2.77	1.91
Telephone lines per 100 inhabitants (destination *comarcas*)	42.78	32.03	44.39	45.80
Telephone lines per 100 inhabitants (origin *comarcas*)	41.30	29.78	42.99	46.95
Housing prices per m^2 (destination) *	151090.81	77405.27	163152.53	177337.34
Housing prices per m^2 (origin) *	141997.57	73285.87	155916.4	164322.16
Number of *comarcas* with known housing prices	---	15	19	22
% Dwellings larger than $150m^2$ (destination)	0.46	0.62	0.72	0.18
% Dwellings larger than $150m^2$ (origin)	0.46	0.62	0.70	0.19
L VECTOR (Labour market)				
% Of commuting into province capitals	0.49	0.51	0.50	0.48
% Resident workers in Agriculture (destination *comarcas*)	0.02	0.03	0.02	0.02
% Resident workers in Agriculture (origin *comarcas*)	0.03	0.04	0.03	0.03
% Resident workers in Construction (destination *comarcas*)	0.07	0.05	0.08	0.15
% Resident workers in Construction (origin *comarcas*)	0.07	0.06	0.08	0.06
% Resident workers in Industry (destination *comarcas*)	0.35	0.39	0.36	0.43
% Resident workers in Industry (origin *comarcas*)	0.36	0.41	0.37	0.32
% resident workers in Non-saleable services (destination)	0.20	0.19	0.19	0.20
% resident workers in Non-saleable services (origin)	0.19	0.18	0.18	0.19
% resident workers in Saleable services (destination)	0.35	0.32	0.33	0.19
% resident workers in Saleable services (origin)	0.34	0.31	0.32	0.38
Population (destination)	1182417.24	1244874.40	1219613.7	1120482.22
Population (origin)	920445.59	983790.12	945414.10	867946.68
Unemployment rate (destination)	0.14	0.24	0.11	0.12
Unemployment rate (origin)	0.14	0.24	0.11	0.12
Average Personal Income Tax (IRPF) (origin *comarcas*)	2144.06	1617.16	2175.71	2455.79
Average Personal Income Tax (IRPF) (destination *comarcas*)	2210.96	1674.12	2246.79	0.32
A VECTOR (Accessibility)				
% Commuting between *comarcas* communicated by subway	0.31	0.34	0.32	0.29
% of commuting between *comarcas* communicated by regional railway services	0.87	0.89	0.87	0.86
% Commuting between adjacent *comarcas*	0.86	0.89	0.87	0.84
Distance	31.57	30.09	31.31	32.53

* : Only *comarcas* with known housing prices are included in the weighted average (see map 1).

TABLE 4: LOGIT MODEL ESTIMATES (1991 AND 1996)

	Model *a* (without real state taxes or migration)		**Model *b1* (with migration, ignoring endogeneity)**		**Model *b2* (with migration, instrumental variables)**		**Model *c* (with real state taxes)**	
Variable	1991	1996	1991	1996	1991	1996	1991	1996
Housing prices (per square m2)	0.16 (11.69)	2.57 (8.03)	0.14 (7.25)	0.80 (2.08)	0.16 (5.52)	0.69 (1.69)	0.18 (9.27)	3.06 (9.03)
% of dwellings > 150m2	-0.01 (3.21)	0.00 (0.01)	-0.01 (3.52)	0.21 (1.47)	-0.01 (2.53)	0.15 (1.06)	-0.011 (3.20)	-0.36 (2.13)
Population	-0.01 (0.88)	0.19 (2.31)	-0.01 (0.85)	0.00 (0.45)	-0.01 (0.86)	0.06 (0.71)	-0.01 (0.49)	0.04 (4.63)
Income tax	2.54 (4.30)	0.63 (1.07)	2.63 (4.42)	4.24 (5.99)	2.54 (4.29)	4.00 (5.41)	2.86 (4.49)	1.75 (2.86)
Unemployment	-0.37 (1.23)	-0.62 (2.22)	-0.33 (1.1)	-0.14 (0.46)	-0.37 (1.12)	-0.35 (1.21)	-0.21 (0.65)	-0.84 (2.88)
Distance	-0.03 (8.04)	-0.03 (9.88)	-0.03 (7.95)	-0.02 (8.53)	-0.03 (7.85)	-0.03 (9.02)	-0.03 (8.03)	-0.03 (10.19)
Contact	1.32 (5.08)	1.03 (4.89)	1.30 (4.98)	1.09 (5.12)	1.32 (4.96)	1.02 (4.76)	1.21 (4.99)	1.04 (4.94)
Migration	---	---	-0.23 (1.41)	-0.59 (9.09)	-0.01 (0.06)	-0.52 (7.69)	---	---
Real State tax	---	---	---	---	---	---	-0.37 (1.37)	-1.33 (4.94)
Intercept	-6.65 (9.79)	-6.16 (8.18)	-6.72 (9.86)	-9.11 (11.02)	-6.65 (9.72)	-8.18 (10.25)	-6.74 (9.93)	-5.76 (7.76)
Hausman Test	---	---	---	---	1.96	19.03	---	---
Adjusted R^2	0.76	0.44	0.76	0.68	0.75	0.63	0.77	0.50

Notes: T-statistics in parenthesis.

Hausman Test is not significant for 1991, but it is significant for 1996.

Instruments used in 1991 are: *% of dwellings > 150m^2; Distance; Income tax; Dummy for flows into capitals; Dummy for flows from capitals; Health facilities index; Education facilities index; Shops per 1000 residents; Cinemas per 1000 residents; % Employed in Agriculture; % Employed in Industry; Average age of dwellings.*

Instruments used in 1996 are: *Housing prices (per square m2); Income tax; Unemployment; Distance; Dummy for flows into capitals; Dummy for flows from capitals; Education facilities index; Health facilities index; % Employed in Agriculture; % Employed in Industry; % Employed in Saleable Services; % of Dwellings with gas pipes; Telephone lines per 100 hab.; Average age of dwellings.*

FIGURE 3: INTER-*COMARCA* COMMUTING

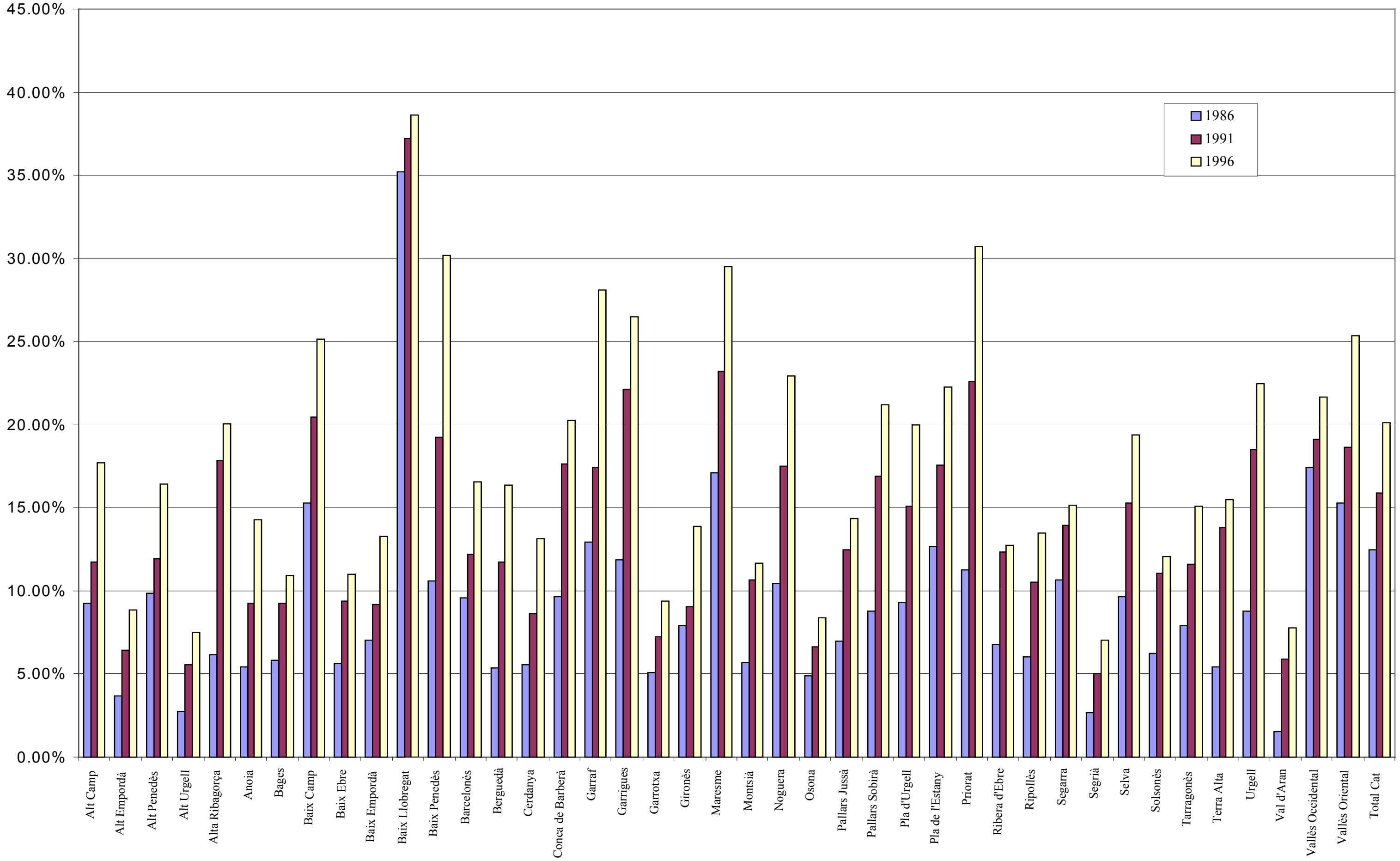


FIGURE 4: INTRA-*COMARCA* COMMUTING